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# BOTANICAL EXPLORATIONS IN THE AMERICAN WEST—1889–1989: AN ESSAY ON THE LAST CENTURY OF A FLORISTIC FRONTIER

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## ABSTRACT

For many Americans the term “frontier” evokes images of cowboys and Indians, but for historians the “frontier hypothesis” is an explanation of the movement and evolution of people and institutions over time from settled urban areas into unexplored regions of remote wilderness. The hypothesis is predictive and may be applied to botanical explorations, the development of floristics models, and the evolution of systematic institutions. The earliest naturalists were lone generalists; they were followed by institutionally sponsored collectors in organized expeditionary groups. These naturalists typically presented their discoveries to urban-situated “professionals,” who published the results. With the settlement of the frontier came local naturalists who published their own discoveries. Published floras evolved over time as each region became settled, with more details being included as the native plants became better known. Initially the first floras were expansive and general. These were followed by concise, descriptive local manuals, which evolved into multivolumed illustrated regional floras with a monographic format. The frontier hypothesis predicts that there should be a westward movement of institutional power caused by increased conservatism in the established eastern institutions coupled with a movement of talented people closer to the frontier. The hypothesis also states that when the frontier ends, there should be a rapid maturation of all institutions along with a reduction in their numbers, more specialization in their missions, a concentration of wealth and power to a few, and a greater uniformity of ideas expressed by all. The key to the future of systematic botany is to fight the tendency to suppress new ideas. With the end of the botanical frontier in the continental United States, the systematic community must decide how it will consolidate its institutions, what its missions will be, and how it will attempt to remain creative.

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For many Americans the term “frontier” evokes the Wild West images of cowboys and Indians. Generations of pulp magazine readers, radio listeners, moviegoers, and now television viewers have grown up with the exploits of Buffalo Bill and Billy the Kid. To the younger generation who missed the weekly adventures of Roy Rogers and Trigger, the association of frontier with the American West might be an odd notion, so for them the concept might best be explained in terms of Hans Solo and the *Millennium Falcon*. No matter the cast of characters or the setting, it is the idea of a frontier that is important here—the concept of one or more adventuresome individuals searching for some unknown in a region that is itself largely unexplored.

The long-romanticized American frontier is distinct in character from the staid colonies of the eastern seaboard, and vastly different from that of Europe, where “frontier” alludes to a boundary between populous nations. The American character was shaped by the frontier experience and this in turn molded a unique civilization. No single event

or feature can be credited with this; our European heritage of customs and institutions contributed but were changed by a mingling of peoples. All eventually were transformed by the industrial revolution and the economic and military growth of the United States into a world power. Taking a step back from these larger trends one finds, as the American historian Frederick Jackson Turner found nearly a century ago, that along the American frontier people and institutions underwent repeated rebirths of civilization at the raw edge of settlement during the four centuries required to cross the continent.

Turner formulated the “frontier hypothesis.” He believed that one of the factors that drove the frontier westward from the fall line along the East Coast was the availability of free land on the edge of advancing settlement. Into that unoccupied wilderness came new immigrants who hoped to better themselves. With them came institutions and traditions of politics, economics, and religious and social customs. These were adapted to fit the more primitive conditions of the frontier, and as the

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frontier moved even further west these modified institutions and traditions changed again.

The primitiveness of the frontier's edge did much to force the reshaping. Highly developed institutions and customs gave way to more simple associations and more pastoral pursuits. After the third century of westward expansion, reaching, as the great arch in St. Louis now symbolizes, the beginning of the trans-Mississippi West, the people, institutions, and customs were already significantly different. Each generation on the advancing frontier had transformed its antecedent with an evolutionary selective process as significant as any seen in the biological world. Adaptation and change were common to all aspects of the frontier existence.

Laws and customs were based on those found just to the east on what previously had been a line of frontier settlement. As each frontier community became more settled, the structure of the institutions became more complex and local customs more sophisticated. Governments and institutions became rigid and conservative with the economic structure specialized. Religious and social customs became stratified into specific beliefs and social classes. In turn, these would be contributed to the adjacent community forming on the edge of the wilderness in a freer, less-sophisticated, and more rebellious form.

Coupled with this was the imposition of the ever-changing local climate and environment. Just as there were continuous rebirths of civilization on the edges of the American frontier, so too did new ways and customs evolve and adapt to the changing environment. To Turner this was significant for it resulted in the "Americanization" of people, customs, and institutions. The American character, he felt, was the result of the evolution and adaptation of society to fit the ever-changing physical environment.

Into this grand equation we now place the plant explorer. By examining this minor character we might better understand: the field of American systematic botany; the historical significance of the large eastern institutions and why it is that the power base is moving westward; the causes leading to an increase in conservative thought and the narrowing of the power base to a few; the increasing failure of institutions with an historical mission of supporting systematics; the concentration of funding and opportunities to do research; and the fleeting importance of the methodologies promoted by the different factions in systematics. Perhaps then we might also better contemplate the future, for as Turner dated the end of the American historical

frontier as 1890, so too must we now date the end of the American floristic frontier as 1990.

What lies beyond is our future. Much as Butch Cassidy and the Sundance Kid left Utah to find a more exciting frontier, so too are many of our systematists leaving temperate North America for the wilds of South America. This is not unexpected because the frontier hypothesis predicts it should be so. In the continental United States we have a known flora and an ever-dwindling number of novelties. With the disappearance of our floristic frontier, so too are those who long for the excitement of the unknown and the thrill of discovering new frontiers.

#### BOTANICAL EXPLORATIONS AND THE FRONTIER HYPOTHESIS

To a significant degree, botanical exploration in the American West is as much a tale of romance and adventure as that of any fur trapper or cowboy. The tales of those who risked life and limb to find a plant simply for its uniqueness and beauty have long been the stuff of novels and television movies.

The first botanical explorers in temperate North America were lone individuals who were nearly always transients. Many were ship's surgeons or ministers. Others were members of the military, surveyors, physicians, or wives. Some collected to win a favor from one of Europe's rich and powerful. But there were real collectors, too, who sailed to America and probed the rich forests along the great rivers and onto the backbone of the Appalachian Mountains. No sooner had paths been pushed through these mountains than naturalists were along them, collecting whatever they could find.

Both the Atlantic and Pacific coasts had early explorers. In the 1600s, plants from the colonies were taken to Europe. A century later, ships from several nations roamed the inlets of the West Coast gathering all kinds of plants, not just trees and shrubs as had been the trend prior to the 1720s. For most Europeans, interest in the flora of eastern North America waned after 1700 with the discovery of the horticultural treasures found in China and Japan, and even the West Coast of North America attracted little interest until the diversity of the inland forests became known in the 1820s. Still, naturalists came.

For the new nation of the United States, science was largely neglected until the presidency of Thomas Jefferson. Jefferson sought and obtained congressional support for a party of explorers to venture up the Missouri River and to cross the



mountains to the Pacific Ocean. They were to survey the natural history and to observe the native peoples and their customs. The land was to be mapped, the features named, and the geology understood. Thus, Lewis and Clark explored the wilderness beyond the frontier at the mouth of the Missouri River. The plants they found were destined to be taken to Europe, described by foreigners, and essentially lost for nearly a century.

Other expeditions followed. One went up the Red River of the Arkansas and another followed the Arkansas itself. Neither was successful scientifically. William Bradbury and Thomas Nuttall, each associated with competing trading companies, traveled up the Missouri River in 1811 to the Mandan villages of North Dakota, but the War of 1812, more thievery, and other unforeseen fates befell the men and their collections, rendering them less significant than they might have been.

On the West Coast, after half a century of coastal explorations by the French, English, and Russians, David Douglas explored the interior and collected hundreds of new species, many of which made their way into European gardens. Like the fur trapper's beaver pelts that were taken to foreign lands where others profited, so too were North American plants sent to Europe where they were described and classified. The exploitation of our natural resources is predicted by the frontier hypothesis and is expected at this stage of development on any new frontier.

European naturalists who sought plants in the North American wilderness after 1800 were often supported by scientific organizations, companies, groups of wealthy men, or governments. For the new nation, there were few formal organizations able to support natural history expeditions, and with almost no wealthy class the task fell mainly to the federal government. Only after the cream of the botanical novelties had been gathered by others did American scientific expeditions begin to move across the continent. Previous generations had found the obvious; this one collected critically.

The year 1850 was significant for by then the frontier was west of the Mississippi River. The gold rush to California was at its height. Texas had been added to the nation, the Oregon question settled, and the land from the crest of the Rocky Mountains to the California coast acquired as a result of a war with Mexico. No sooner had the frontier come within sight of the western boundary of the United States than a vast new wilderness was added to the nation's map. Still, there were scattered settlements on the fringes. The Oregon, California, Mormon,

Santa Fe, and Spanish trails were in constant use. Farming communities had been established in the Central Valley of California and the Willamette Valley of Oregon, and the Mormons had arrived in Utah. The small mission villages along the California coast from San Diego to San Francisco had been augmented by a series of boom towns dotting the foothills of the Sierra Nevada, and gold and silver would soon be found elsewhere. To the north, the old forts of the Hudson Bay Company were giving way to new fishing, lumbering, and farming communities.

As before, naturalists came to the frontier, crossed it into the botanical wilderness, but in doing so came to a new frontier moving eastward. The unexplored regions of the American Southwest and the Great Basin attracted greater attention, with the two massive cordillera, the Rocky Mountains, and the Sierra Nevada-Cascade Range bringing many to search for their novelties. Government expeditions to map the interior of the American West provided numerous opportunities for naturalists to explore remote regions. On both edges of the frontier, institutions were being established, indicating a higher generational order near the frontier. In St. Louis, George Engelmann and Henry Shaw were joining forces and the forerunners of the Missouri Botanical Garden were taking shape, while in San Francisco, a group of naturalists led by Albert Kellogg were coming together to establish the California Academy of Sciences.

The Civil War years of the 1860s, and then a decade of Indian wars in the 1870s, took their toll on scientific efforts. Many naturalists who might otherwise have gone west in search of scientific curiosities were delayed or hesitant. When the turmoil ended, many went west, some to become local amateur naturalists, some to be professional collectors, and a few to serve in the new scientific military or to join the few academic institutions offering botany. In time, as Congress reduced the role of the military, more and more of the scientific research done in the wilderness was carried out by civilian agencies.

By the 1870s, the wilderness beyond the frontier was restricted to the Rocky Mountains, Great Basin, and desert regions of the Southwest. Into these areas, as predicted by the frontier hypothesis, came lone naturalists in this rebirth of civilization on the botanical frontier. This generation was more educated and critical than previous ones, reflecting the increased sophistication of their immediate ancestors. Some were supported by the federal government, but many were associated with colleges or



with scientific institutions. To a lesser extent, some were private collectors interested in selling their specimens. Most came to the frontier and entered the wilderness only for the growing season, but by the 1880s, some devoted all of their energy to settling the American, as well as the botanical, frontiers.

In its simplest form, the closure of the American frontier in 1890 was signified by the settlement of the land by people. The botanical frontier lagged behind for there were still remote regions to be explored for their botanical treasures. The lure of new species drove naturalists into the wilderness where the discovery of novelties was still routine. For the botanical frontier to close, those remote regions had to be explored and their botanical novelties discovered.

#### THE CLOSING OF THE BOTANICAL FRONTIER

The last century of botanical explorations and discoveries, the writing of floras and florulas, and the development of today's botanical institutions did not occur in a vacuum. There was a past, and that past molded what is in the present. Numerous collectors came to temperate North America before and during the Linnaean era, and these collections were used by Carl Linnaeus to describe nearly 900 species from temperate North America in his 1753 two-volume work, *Species Plantarum*; the majority were based on specimens obtained by just two men, John Clayton and Pehr Kalm. Even the majority of North American plants named by Linnaeus after 1753 were based on the collections of John Bartram alone.

The exploits of post-Linnaean naturalists in eastern temperate North America did much to settle that floristic frontier by 1825 with Thomas Walter, John Fraser, André Michaux, Frederick Pursh, Thomas Nuttall, Stephen Elliott, Jacob Bigelow, John Torrey, and Amos Easton being major contributors to the effort.

While Nuttall continued to explore on the edge of the frontier, Torrey remained in the floristically settled East where he rose to a position of influence and became the first to dominate systematics in temperate North America. That mantle was soon passed on to Asa Gray at Harvard University, who became the single most influential man in our frontier history. Together, Torrey and Gray imposed their will up to 1889.

To settle in a wilderness is not to conquer it. Although Torrey and Gray did much to describe the flora of temperate North America, much like

Linnaeus before them, they too relied upon others to discover the novelties. It was those people who closed many of the botanical frontiers across the continent.

For the Northeast, Torrey and especially Gray made substantial contributions. They were followed at Harvard by Sereno Watson, Benjamin L. Robinson, and Merritt L. Fernald, all of our "century," 1889–1989. These men had a competitor in the form of Nathaniel Lord Britton and later Henry A. Gleason at the New York Botanical Garden. Each man championed a series of flora projects, students, and institutions as shall be noted below. The honor of closing the floristic frontier in the Northeast, however, must be granted to Fernald. In 1950, following nearly half a century of devoted fieldwork on his part and a careful study of type material, Fernald published a fitting tribute to all who had followed Asa Gray.

The richness of the southeastern United States was discovered initially by the likes of Mark Catesby, Thomas Walter, and the father and son teams of Bartrams and Michauxs. Overlapping our century were Alvan W. Chapman, Samuel B. Buckley, and John L. Riddell. John K. Small did much to reduce the botanical frontier in the South during the first half of our century, but only now, thanks to the efforts of Robert W. Long, Olga K. Lakela, Robert K. Godfrey, Daniel B. Ward, and Walter S. Judd in Florida, Albert E. Radford, C. Ritchie Bell, and their colleagues in the Carolinas, and Delzie Demaree, Robert Kral, M. Murray Evans, and R. Dale Thomas elsewhere in the South, has its botanical frontier closed.

The flora of the Old Northwest was almost always considered synonymous with that of the Northeast, a fact reflected by the regional floras of the area. The university community was active in the search for new species, but the individuals were largely dominated by those at Harvard and New York. State floras were written and are now being written, but without a definable region where novelties are to be expected, one must conclude that the botanical frontier ended in 1950, when it closed in the Northeast.

Early plant explorers on the Great Plains were mainly transients who hurriedly crossed the region to get to the mountains of the West. The Great Plains were the deeded home of many American Indians, and travel off established routes was rarely done. With the gradual demise of the Plains Indians, and in the 1860s and 1870s the loss of their homeland, plant explorers were able to penetrate beyond the limits of the frontier trails established by the cattlemen, miners, and cavalry. Even the



resident naturalists were often transient. Albert S. Hitchcock left Kansas for Washington in 1901, and Per Axel Rydberg left Nebraska in 1895, eventually accepting a position at the New York Botanical Garden in 1899.

Unlike in the Old Northwest, specimens collected by resident plant explorers on the Great Plains tended to remain in local university herbaria. This was, in part, because the Great Plains were sufficiently far enough removed from the eastern centers to evoke a degree of independence, but also the men and institutions themselves had come from a more isolated, former frontier. Persons like Charles E. Bessey in Nebraska and Theodore D. Cockerell in Colorado collected for years, trained numerous students, and built large herbaria. To be sure, outsiders continued to come to the Great Plains, and there were other resident naturalists who collected throughout much of the area, yet credit for closing that botanical frontier must be granted to the late Homer A. "Steve" Stephens, who made some 90,000 collections before he retired in 1975.

Botanical explorations in Texas began in 1828 with Jean Louis Berlandier, who was followed by Thomas Drummond in 1833, by Ferdinand J. Lindheimer, Auguste Trécul, and Charles Wright in the 1840s, and by Julien Reverchon, who collected from 1870 to 1885. The remarkable diversity across the state, to say nothing of its size, meant that the botanical wilderness in Texas was more a series of pockets than a single definable line. The work of Victor L. Cory, Lloyd H. Shinnars, Barton H. Warnock, Frank W. Gould, Donovan S. Correll, Billie L. Turner, and Marshall C. Johnston led ultimately to a 1970 flora of Texas and brought its floristic frontier to an end.

The West Coast floristic frontier differed dramatically from its eastern counterpart in many aspects besides the great diversity in its flora. Here naturalists were often far in advance of others in the exploration of the West, and the naturalists demonstrated their independence and adventuresomeness by their very presence. Most significant of all, they were well isolated from the eastern establishment so that they were able to make critical decisions on the future of their profession.

At first the discoveries were slow. Jean-Nicolas Collignon collected the first plants near Monterey, California, in 1786—some 280 years after the first plants were taken to Europe from the East—and Jean Baptiste Lamarck described the first trans-Mississippi species, *Abronia umbellata*, in 1791. The Spanish, English, Russian, and American governments sent other botanical explorers to the West

Coast so that the roster of collectors grew rapidly, but it was David Douglas who was destined to be the most formidable, for he forced the botanical frontier away from the Pacific Ocean. Others entered the Pacific Northwest by land, following the Oregon Trail with Nathaniel J. Wyeth, Thomas Nuttall, Karl A. Geyer, and John C. Frémont following that same route. Since 1889, many have devoted much of their professional life to closing its botanical frontier.

In Washington, Wilhelm M. Suksdorf, Charles Vancouver Piper, R. Kent Beattie, F. Marion Ownbey, and Harold St. John explored many parts of the state. Fieldwork was done in Oregon by Thomas Jefferson Howell, William C. Cusick, and Morton E. Peck, with lesser contributions made by Louis F. Henderson and LeRoy E. Detling. More recently, Helen M. Gilkey and Kenton L. Chambers and their students and associates have been actively collecting in the state. In adjacent Idaho, naturalists tended to pass through the region rather than explore it for its novelties. Still, the team of John H. Sandberg, John B. Leiberger, Daniel T. MacDougal, George Vasey, and Amos A. Heller collected extensively in northern Idaho around the turn of the century. Louis F. Henderson of the University of Idaho concentrated his efforts in eastern Idaho, and Aven Nelson of the University of Wyoming and several of his students, including James F. Macbride and Edwin B. Payson, collected in Idaho during the first two decades of this century. John H. Christ of the Soil Conservation Service collected nearly 10,000 numbers in the 1930s when Ray J. Davis, who started the herbarium at Idaho State University in 1930, was encouraging others to collect. Among Davis's students were Arthur Cronquist and my own father, Jack L. Reveal, who gained a lifelong appreciation of grasses from Davis.

The team of C. Leo Hitchcock and Clarence V. Muhlick actively collected throughout the Pacific Northwest. It is to them and to 1973, when Hitchcock retired, that one must credit the closing of the floristic frontier in the Pacific Northwest.

The diverse flora of California has long attracted botanists. Its botanical frontiers moved away from the coast into the mountains and deserts early in its history so that California had its own published flora by the mid 1870s. The cast of post-1889 characters was, and even today is, remarkable.

Mary Katherine (Curran) Brandegee and Alice Eastwood are two of the more notable characters. Both collected actively throughout much of the American West. Their lives were closely interwoven as Eastwood succeeded Brandegee, in 1894,



as the curator of botany at the California Academy of Sciences. Both had ardent followers and supporters, and each in turn promoted botany as a science. The university scene was equally gifted with the likes of Willis L. Jepson, who replaced Edward L. Greene in 1895, and like Eastwood, remained active in botanical explorations for half a century. At Stanford University, the reign of William R. Dudley began in 1892, with LeRoy Abrams joining the staff in 1902. Berkeley and Stanford graduated many students who continued explorations in California. Jepson students included Harvey Monroe Hall, who graduated in 1906; Ivan M. Johnston, John Thomas Howell, David D. Keck, and Conrad V. Morton, all of whom graduated in the 1920s; and Lincoln Constance, who finished his degree in 1934. Herbert L. Mason went from Stanford to Berkeley, receiving his doctoral degree in the early 1930s whereupon he joined the Berkeley staff. Also from Stanford were such active collectors as Elmer I. Applegate, Ira L. Wiggins, Charles Piper Smith, and Roxana J. Ferris.

Numerous collectors were associated, in some fashion, with each of the three institutions in the San Francisco Bay region. At the Academy, where John Thomas Howell held the curator's chair after Eastwood, numerous knowledgeable "amateurs" came for guidance. The list is long, but one cannot ignore the likes of Ernest C. Twisselmann, Gordon True, or Gladys L. Smith. Samuel B. Parish and Charles Russell Orcutt, both active in southern California from the 1880s until the 1920s, contributed their personal herbaria to Stanford. Adolph D. Elmer collected widely in California, with his specimens going to Stanford.

Numerous individuals were attracted to Berkeley. Ethel K. Crum, Annetta M. Carter, Helen K. Sharsmith, and Lauramay Dempster each made significant collections. Contributing their herbaria to Berkeley were such collectors as John Gill Lemmon, Joseph P. Tracy, and Ira W. Clokey. In addition to the large collections made by Jepson, Mason, Constance, and more recently Robert Ornduff, who were on the Berkeley faculty, the efforts of Jepson Herbarium staff, notably Rimo Bacigalupi and Lawrence R. Heckard, made great inroads into many rarely collected portions of California.

In southern California, Pomona College came to be the focal point of plant explorations and systematics. Philip A. Munz, who became director of the nearby Rancho Santa Ana Botanic Garden, was deeply involved in floristics. From 1917, when he joined the college's faculty, until his death in 1974, Munz was devoted to the California flora and made numerous collections. His students read

like a "who's who" in plant explorations both in California and beyond: F. Raymond Fosberg, C. Leo Hitchcock, George J. Goodman, David Keck, and Louis C. Wheeler are just a few. Munz concentrated his efforts in the mountains and deserts of southern California, but made occasional excursions to the North. His student and eventual colleague Lyman D. Benson was also a formidable collector, albeit more specialized.

The basis of the Pomona College Herbarium was the private herbarium of Charles F. Baker, who amassed a collection of some 100,000 specimens. To this, Munz added the herbarium of Marcus E. Jones in 1923; it too numbered approximately 100,000 sheets. The collections of Frank W. Peirson, M. French Gilman, Percy C. Everett, and Carl B. Wolf may now be examined at the Rancho Santa Ana Botanic Garden.

In the years since Munz died in 1974, many new species have been found by persons willing to explore the most remote portions of California. Mary C. DeDecker discovered *Dedeckera*, which was described in 1976, and James R. Shevock is still uncovering novelties. Yet, the finds are few and generally scattered so that it seems appropriate to close California's botanical frontier in 1976, a century after the state's first flora was published.

The Rocky Mountains have always attracted the botanically curious. When Joseph Dalton Hooker came to America in 1877, Asa Gray took him to the Rockies. Numerous naturalists came by train to spend the summers in the coolness of their height and to regale in their splendor. In 1889, no other region of the United States was attracting such a diversity of botanists. Per Axel Rydberg, Marcus Jones, and Joseph W. Blankinship did much to explore previously unstudied portions of Montana, with Charles Bessey sometimes joining Rydberg. C. Leo Hitchcock collected in western Montana, especially during his tenure at the University of Montana from 1932 until 1937. Several university-based professors and their students have climbed the mountains in search of plants, with the "amateur" Klaus Lackschweitz among the forefront of recent collectors.

Aven Nelson is synonymous with floristics and Wyoming. This remarkable man, a botanist, teacher, and president of the University of Wyoming, was productive throughout his 97 years. He collected widely in the state, expanding its floristic frontier away from the narrow Oregon Trail and Central Pacific Railroad route where nearly all before him had concentrated their efforts. He encouraged others to collect, and the students he influenced to continue in systematic botany are



now legendary: Elias E. Nelson, Leslie N. Gooding, James Francis Macbride, Edwin and Lois E. Payson, George J. Goodman, Louis O. Williams, and Reed C. Rollins. C. L. Porter, who came to the University of Wyoming in 1929, continued the tradition of exploring the wilds, concentrating in the 1930s on bryophytes and then vascular plants. The massive field efforts by Ronald Hartman in the 1980s, although still demonstrating the need for additional fieldwork, have conquered the last vestiges of a botanical frontier in Wyoming.

The Colorado Rockies have been a beacon to naturalists since the first specimens were taken by Thomas Say and Edwin James in 1820. The work of Cockerell, Rydberg, Charles Penland, George E. Osterhout, Harold D. Harrington, and a host of others who have explored the Rockies since 1889 have allowed William A. Weber of the University of Colorado, long a persistent and diligent collector, to be the last to collect on its botanical frontier.

Across the American Southwest, the floristic frontier moved slowly, being pinched in from both the East and the West. The first to collect in New Mexico was William Gambel, who traveled the Old Spanish Trail from Santa Fe to Los Angeles. During the war with Mexico, Major William H. Emory, Lieutenant James W. Abert, and Charles Wright entered New Mexico, collecting specimens whenever possible. Augustus Fendler and Friedrich A. Wislizenus arrived in Santa Fe with Emory and his "Army of the West"; Fendler remained in New Mexico collecting in the mountains to the north while Wislizenus turned southward into Mexico. Thomas Coulter was the first to explore Arizona botanically, visiting Yuma in 1832. Naturalists associated with other military expeditions, and especially the Corps of Topographical Engineers, discovered numerous botanical novelties. The most important collector of our "century" was Edward Palmer, who gathered plants in the Southwest for nearly 40 years. Others have searched for plants, with many finding a surprising number of novelties in the more remote regions since 1930. The floristic frontier in the Southwest was gradually reduced through the efforts of Forrest Shreve, Thomas H. Kearney, and Robert H. Peebles. The botanical wilderness finally disappeared along the border of central Arizona and New Mexico in the 1980s through the efforts of Donald Pinkava in Arizona, Richard Spellenberg in New Mexico, and their many colleagues and students.

The floristic frontier swept into the Intermountain West from all directions. The historical California and Spanish trails to the Pacific Coast had been rapidly botanized prior to 1889. Like in the

Southwest, many military-sponsored expeditions crossed Utah and Nevada, with the geological surveys led by Clarence R. King, and especially by John Wesley Powell and George M. Wheeler, putting their botanists into exceedingly remote areas. The university communities in Utah and Nevada encouraged botanical explorations by their faculty, and the faculty in turn encouraged numerous students. Among the more significant were Amos A. Heller and Patrick B. Kennedy of the University of Nevada, and Walter P. Cottam and Seville Flowers of the University of Utah.

The post-1889 history of botanical explorations in the Intermountain West cannot be told without a brief mention of Marcus Eugene Jones. He set out to explore the whole of the "Great Plateau," as he termed the Intermountain West, and succeeded in traveling throughout most of it. He collected wherever he went and described many narrowly endemic species as he amassed his herbarium. While Jones lived in Salt Lake City (1880 to 1923), he carefully guarded the frontier with his biting pen and his quick printing press. Those who ventured upon his territory were all too often destined to be the subject of his scorn. His desire to write a "Flora of the Great Plateau" eluded him, however, and the manuscript was still unfinished when he died in a car accident in 1934.

Many botanical teams came to the cold deserts in search of plants. Eastwood and Howell were active in the 1930s and 1940s, with H. Dwight Ripley and Rupert C. Barneby, Bassett Maguire and Arthur H. Holmgren, and Annie Alexander and Louise Kellogg continuing the trend into the 1950s. Noel Holmgren and I collected together in the 1960s, with N. Duane Atwood and Larry C. Higgins replacing us in the 1970s. Arnold "Jerry" Tiehm and Margaret Williams, working mainly in Nevada, were active in the 1980s.

Stanley L. Welsh and his students and associates at Brigham Young University moved the floristic frontier westward across Utah into Nevada, closing it for Utah in 1987. In Nevada, Tiehm, who discovered a wealth of new species in isolated portions of Nevada, completed the task and may be considered the last to have explored on the botanical frontier in the continental United States.

#### THE EVOLUTION OF FLORISTIC STYLES ON THE AMERICAN FRONTIER—1889–1989

Many of the early floras treating the known plants of the world included species that had been collected on the edge of whatever frontier existed at the time. Among the early settlers were men



and women willing to collect natural objects for others to study. Occasionally, some desired to publish their own findings, but events and others usually conspired to prevent this, as happened to John Clayton whose manuscript of the flora of Virginia was published by Gronovius, with the help of Linnaeus, in 1739 and 1742. Forty years later, Thomas Walter's *Flora Caroliniana* was edited and published in London by John Fraser. The French naturalist, André Michaux, who explored on the edge of the frontier in eastern Canada and the United States, did write his own 1803 *Flora Boreali-Americana*, but many still believe it was actually the work of L. C. Richard. One of the first American books devoted to the plants of a region was the little-known 1808 *Flora Carolinaeensis* published in Charleston, South Carolina, by John Shecut. This work was designed for the physician. It contains excellent descriptions and surprisingly well-informed distribution statements. Only one of its two volumes was published. Frederick Pursh, after spending several years in the United States, published his 1814 *Flora Boreali-Septentrionalis* in London.

Most floristic manuals treating the plants of temperate North America prior to 1814 were at best general approximations of the diversity. The style was Linnaean—short descriptions and a brief statement regarding distribution—as was the classification (Shecut being an exception in all respects). Both were dictated by strong historical ties with England and the influence of James Edward Smith and others of the “Linnaeans” then in London. The transition in styles and formats may be seen in the 1814 *Florula Bostoniensis* by Jacob Bigelow, who maintained the concept of the Linnaean diagnosis, but added a more detailed description for those plants he knew from the field. He also provided a common name for each species. In *A Synopsis of the Genera of American Plants* published in Georgetown by J. M. Carter, also in 1814, one finds a key to the classes and orders, but the descriptions themselves are classically Linnaean.

In Stephen Elliott's *A Sketch of the Botany of South-Carolina and Georgia* (1816–1824) the diagnoses are expanded and given in both Latin and English. A full description of each species was given with the characters arranged in a manner not unlike a modern flora. Elliott provided information on abundance and the time of flowering, and cited previous places of publication and illustrations.

The use of “natural orders,” or what we would term “families,” in floras was highly debated at this time. Most works, such as William Barton's

*Compendium Florae Philadelphicae* and Thomas Nuttall's *Genera of North American Plants*, both published in Philadelphia in 1818, followed the Linnaean system with the genera artificially arranged in nearly 60 classes and orders. In 1789, A. L. de Jussieu had proposed 100 natural orders, and these were coming into use, especially in Germany. The first North American work to use natural orders was *Florula Ludoviciana*, published in New York by Constantine Rafinesque in 1817. Two years earlier, Rafinesque had proposed more than 300 natural orders. Amos Eaton was more cautious in his 1817 *Manual of Botany*. He arranged his plants following Linnaean principles, but in his introduction he presented an outline of the Jussieu system, complete with descriptions, representative genera, and medical uses. He also provided a glossary. Unique to this work, the genera were described in one section with the species accounted for in another. A habitat statement was given, but where in “the northern and middle states of America” the plant was found was not provided.

Torrey's *A Flora of the Northern and Middle Section of the United States*, dedicated to Thomas Nuttall, appeared in 1823 and 1824. True to his heritage, he arranged plants in the Linnaean fashion. The genera were briefly described, with references given to previously published descriptions and synonymy. He also provided a common name. However, he noted the natural order that each should be assigned.

The professional union of John Torrey and Asa Gray was to alter immediately the style of American floras. The Americans were no less grandiose in their plans for continental floras than their European counterparts. The first part of William Jackson Hooker's *Flora Boreali-Americana* appeared in 1833, and in 1838 Torrey and Gray began their own never-finished *A Flora of North America*. Like other efforts of its kind, the project suffered from an overwhelming amount of new material that could not be readily summarized.

For the evolution of floristic models, however, this was to be a significant work. The usefulness of natural orders in classifying plants had been amply demonstrated by John Lindley in 1830, with the publication of his *Introduction to the Natural System of Botany*, and he had swept away the last influences of the Linnaean sexual system on plant classification. Gray was an ardent follower and incorporated the concept in the *Flora*, going so far as to provide dichotomous keys to the families based on those in Lindley's 1835 *A Key to Structural, Physiological, and Systematic Botany*, and even to genera as seen in S. F. Gray's *A Natural*



*Arrangement of British Plants* (1821). There were no keys to the species; rather, Torrey and Gray provided diagnostic headings to groups of species following the format designed by A. P. de Candolle for the *Prodromus*.

More practical regional floras began to dominate the floristic scene, with the majority written for the settled portions of the United States. John Darby published *A Manual of Botany Adapted to the Productions of the Southern States* in 1841. Gray responded in 1848 with the first edition of his *Manual*, which was a comparable treatment for the plants of the northern states. The first edition of Chapman's *Flora of the Southern United States* was published in 1860. In all of these works, the plants were arranged in families, keys to the families were provided, and some means were provided which allowed one to discriminate among the various groups of species. Works for students began to appear as well. Gray published the first edition of his *Elements of Botany* in 1836. Alphonso Wood's *Class-book of Botany*, initially published in 1845 and variously titled, underwent many revisions and editions, selling perhaps a million copies over the next 50 years. For those at female seminaries there was Mrs. Lincoln's *Familiar Lectures in Botany*. Gray and Wood followed Lindley. Wood's key to the families, however, was bracketed and only partially dichotomous; Mrs. Lincoln tended to retain the Linnaean model.

In addition to floristic studies, a growing number of naturalists began to specialize on groups of plants. Mosses, bryophytes, ferns, grasses, and even certain genera of flowering plants became the focus of intense study. As Gray's career evolved during his lifetime, he too became an authority on a multitude of families (notably Asteraceae) and such diverse genera as *Eriogonum* and *Penstemon*.

For those who were on the western frontier, however, the aging Gray eventually became an impediment as he seemed to become increasingly more rigid and demanding that his authority not be questioned. To the independent westerner this was intolerable, and a revolt began in the form of defiance by Edward L. Greene, Marcus E. Jones, and others who lived and worked on the floristic frontier. It was traditional for most new species to be sent to Gray for evaluation and approval. After the mid 1870s, evaluation was left to Sereno Watson who, like Gray, was at Harvard University. Approval was not guaranteed. Furthermore, editors often submitted articles to Gray or Watson for comment. Some westerners alleged that their new species were thus delayed awaiting Gray or Watson to describe the same plant from material in their

own holdings. Later, Per Axel Rydberg required some western authors to submit vouchers with their manuscripts so that he could make his own evaluation of their new species. It was this pretense of eastern superiority that many on the floristic frontier resented and rebelled against. The result was sectionalism and its expression was in the form of a host of privately published journals.

Books, manuals, and regional floras were difficult to write and expensive to publish on the frontier. Most westerners had limited resources and thus it was simpler to publish new species. Botanical journals are, even today, the bread and butter of the systematic community, but they were not common prior to 1900 and most were restrictive in some fashion. The *Transactions of the American Philosophical Society*, one of the first American journals, began in 1771, and the *American Journal of Science* started in 1818. The *Proceedings of the American Academy of Arts and Sciences*, long the journal used by Gray and Watson, began in 1846. Institutional journals first appeared in 1817 when the *Journal of the Academy of Natural Sciences of Philadelphia* was established; it was followed by *Smithsonian Contributions to Knowledge* in 1848. Some local and regional western American academies had their own publications. The *Proceedings of the California Academy of Sciences* published its initial volume in 1854. The *Transactions of the Academy of Science of St. Louis* had its origin in 1860. Current journals, such as the *Bulletin of the Torrey Botanical Club*, began in 1870; this was soon joined by the *Botanical Gazette* in 1875 and *Rhodora* in 1899. These three eastern-dominated and establishment-sponsored journals were soon the primary outlets for individuals who were not associated with an institution to propose new species. With the advent of open journals, the institutional ones often became largely even more restricted. Examples include the Smithsonian's *Contributions from the United States National Herbarium* (1890), Harvard's *Contributions from the Gray Herbarium* (1891), Chicago's *Publications of the Field Columbian Museum* (1895), and the *Bulletin of the New York Botanical Garden* (1896). The ancestor to the *Annals of the Missouri Botanical Garden*, which began in 1914, was the *Annual Report of the Missouri Botanical Garden* (1890).

To isolated, independent westerners, these journals were either unavailable or the editorial policies made it difficult for them to publish their findings. To a substantial degree each journal was edited by a strong personality who had political, economic, or institutional reasons for excluding the works of



outsiders. Most of the dissidents had earned their reputation as a “botanical pest” (to quote one of them speaking of another) so that very often there were sound scientific reasons why an editor should be cautious. As a group, the westerners were a quarrelsome lot—if one made an error, another would immediately write the editor to complain.

Another factor for the independent western journals, and one predicted by the frontier hypothesis, was the need to establish an independent identity. What better way than by a scientific journal? The proliferation was immediate: Greene began *Pittonia* in 1887, Townshend S. Brandegee and Mary Katherine Brandegee started *Zoe* in 1890, and Jepson released the first issue of *Erythea* in 1893. Heller started *Muhlenbergia* in 1900, and Marcus Jones began his *Contributions to Western Botany* series in 1902.

With Gray's death in 1888, one year before our “century” began, the domination of the eastern establishment weakened and Watson, Robinson, and Fernald, who followed Gray at Harvard, never gained his stature and respect. Britton and Rydberg at New York, and John Merle Coulter in Washington, further weakened Harvard's importance by imposing their own forms of domination.

Still, western floras were written. The initial efforts came in the form of a cooperative effort between a university and a state agency. William H. Brewer of the California Geologic Survey and Watson of Harvard University published the first volume of their flora for the state in 1876. Volney Rattan followed with his privately published *A Popular California Flora* in 1879. Greene, who became professor of botany at the University of California in 1885, privately published the first part of his *Flora Franciscana* in 1891. At Wabash College, Coulter compiled a *Manual of Botany of the Rocky Mountain Region*, which was published in 1885. These floras followed the format developed by Gray for his *Manual*. There were no innovations except by Brewer and Watson, who had sections devoted to discussion much as seen in Torrey and Gray's *Flora*, but heretofore not found in a local flora.

Prior to 1900, keys to species were not common in floras and only rarely seen in revisionary studies. One of the innovations in the three-volume *An Illustrated Flora of the Northern United States, Canada and the British Possessions* by Britton and Brown was the use of indented, dichotomous keys to the species. The idea was probably adopted from the Berlin-based taxonomists who routinely provided keys to species in their works. The innovation was immediately adopted by western au-

thors. For example, keys are lacking in Coulter's *Flora of Western Texas*, published in 1891, in Frederick V. Coville's 1893 report on the *Botany of the Death Valley Expedition*, and in Thomas Jefferson Howell's *Flora of Northwest America* (1897). But Jepson, who replaced Greene at Berkeley in 1895, included keys in his suite of studies on the plants of that state. In the 1901 *A Flora of Western Middle California*, Jepson indicated that his keys to family, genera, species, and in some instances even varieties, were designed to “apply only to the species listed” and that—as many can appreciate today—he had spent a “very great amount of time and effort” on their construction. He maintained the same degree of care in his other efforts: *A California Flora* (1909) and his condensed treatment *A Manual of the Flowering Plants of California* (1923). Jepson was as aware of the student market as Gray, Woods, or Britton. In 1902 he published *A School Flora for the Pacific Coast*. My first taxonomic work was Jepson's *A High School Flora for California*, which I used as a freshman at Sonora Union High School in 1955, 30 years after its initial publication.

One of the major evolutionary changes in floristic design that may be attributed to Jepson was the monographic style he developed for his *A California Flora* series. Like Gray before him, and his contemporaries Britton and Fernald, Jepson examined type material and wrote extended comments about each species. While on Jepson, it should be mentioned that he started the *University of California Publications in Botany* in 1902, which was an institutional journal, and was the first editor of *Madroño*, the journal of the California Botanical Club; it was first published in 1916.

LeRoy Abrams, who arrived at Stanford University in 1902, published a *Flora of Los Angeles and Vicinity* in 1910 in cooperation with the New York Botanical Garden, and in competition with Jepson, published the first volume of his *Illustrated Flora of the Pacific States* in 1923. Abrams adopted the illustrated flora format of Britton and Brown. Like them he included synonymy and provided each species with a common name. Unlike his eastern counterparts in this regard, Abrams fabricated the names; Britton and Brown had evidence for their use.

The Smithsonian Institution began its western campaign by publishing a series of local and state floras in the *Contributions*. The *Flora of the State of Washington* by Piper appeared in 1906, and Elmer O. Wootton and Paul C. Standley published their *A Flora of New Mexico* in 1915. A decade later, Ivar Tidestrom's *Flora of Nevada and Utah*



was published. The format of each book was a series of descriptive keys with distribution and ecological data added in an adjacent section. The detailed descriptive format of the Harvard- and New York-based floras was deleted. By the 1930s, this was the trend in most federally supported flora projects such as Kearney and Peebles's 1942 *Flowering Plants and Ferns of Arizona*.

The New York Botanical Garden was also extending its influence into the West. Rydberg's *Flora of Colorado* was traditional in format, but following the lead of his colleague John Kunkel Small, who was engaged in floristic studies in the southeastern United States, Rydberg later adopted a concise floristic style in his 1917 *Flora of the Rocky Mountains and Adjacent Plains* and his 1932 posthumously published *Flora of the Prairies and Plains of Central North America*. These works, with their precise keys and sparse but detailed descriptions, became the model that many others have copied.

The first modern manual was Fernald's *Gray's Manual of Botany*, published in 1950. It was carefully written, with detailed descriptions and excellent distribution and habitat data given for each species. In the descriptions, Fernald highlighted the diagnostic features of each species in italics. *A California Flora*, published by Philip A. Munz in 1959, also had excellent descriptions and distribution data. While Fernald illustrated an occasional species, Munz illustrated each family. The model developed by Munz was adopted by Correll and Marshall C. Johnston in their *Manual of the Vascular Plants of Texas*, published in 1970.

When the Pacific Northwest and Intermountain West floras were in their early planning stages in the 1950s under the influence of the New York Botanical Garden, Arthur Cronquist and C. Leo Hitchcock decided to merge various flora designs into two publications. The first was to be a multi-volume, large-format, illustrated, monographic work with room for ample discussion. The second was to be a concise one-volume manual. The five-volume *Vascular Plants of the Pacific Northwest* was published from 1955 to 1969, with the one-volume *Flora of the Pacific Northwest* appearing in 1973. The latter work followed the expanded key-format of the Smithsonian-based series, but added illustrations along the margin of each page.

The first volume of the *Intermountain Flora* was published in 1972 with an expanded introduction. This format is being followed in the new multivolumed flora of North America north of Mexico.

As might be expected, as newer models for floras

evolved in the West, they were later adopted by writers in the East. Strausbaugh and Core began publishing their illustrated *Flora of West Virginia* in 1952. The *Manual of the Vascular Plants of the Carolinas*, by Radford, Ahles, and Bell appeared in 1968; it included distribution maps. The two-volume work on the vascular plants of Maryland by Russell G. Brown and Melvin L. Brown used color photographs and line drawings. They also annotated their illustrations so that in many instances it is possible to key out a plant merely by examining the figures. The *Flora of the Great Plains* is a two-volume work, with one dedicated to distribution maps and the second a descriptive manual modeled after those written in California and Texas. Two excellent Midwest floras are being published currently: *The Illustrated Flora of Illinois* by Robert Mohlenbrock and *Michigan Flora* by Edward Voss. These are monographic in style, but the books are of a smaller size so that it will require several volumes to complete the work.

Specialized manuals rapidly came into being as well as the more general flora. While illustrated silvas were common, dating back to those by F. A. Michaux (1841–1842) and Nuttall (1842–1849), Charles Sprague Sargent's *The Silva of North America*, published from 1890 to 1902, is the best known. Other specialized manuals were published as well: the *Manual of the Grasses of the United States* by A. S. Hitchcock first appeared in 1935, with a revision by Agnes Chase released in 1952. *A Manual of Aquatic Plants* was published by Norman C. Fassett in 1940 and in a revised edition by Eugene C. Ogden in 1957. This illustrated manual led to Mason's *A Flora of the Marshes of California* in 1957, which led to *Aquatic and Wetland Plants of Southwestern United States* by Donovan S. Correll and Helen Correll in 1972. The latter was followed by a companion work for the southeastern United States by Robert K. Godfrey and Jean W. Wooten in 1981. Kenneth K. Mackenzie's 1940 *North American Cariceae* is reminiscent of the kind of illustrated works published in the 1700s in Europe.

The increased popularity of wildflower books with fine illustrations or photographs evolved into informative works on American trees, mosses and bryophytes, fungi, lichens, and algae. One of the first western books was *The Wild Flowers of California* written by William Doxey and published in 1897. Harold W. Rickett's series of books published from 1966 to 1973 on the wildflowers of the United States with its elegant colored photographs has become a classic of its kind. The same may be said of Carlyle A. Luer's two volumes on



the orchids of the United States and Canada published in 1972 and 1975. The scholarly *A Field Manual of the Ferns & Fern-allies of the United States*, published in 1985 by David Lellinger, is illustrated by a series of excellent color photographs taken by A. Murray Evans.

Numerous checklists and local florulas have been published for portions of many states, especially in western America. John Thomas Howell in California and Stanley L. Welsh in Utah have authored or assisted in many such publications. Recent works have been published for Louisiana and other states in the Deep South.

Two trends have evolved over the past 30 years. First, many manuals are so expensive that some—notably the 1980 *A Flora of New Mexico* by William C. Martin and Charles R. Hutchins, and Robert D. Dorn's 1977 *Manual of the Vascular Plants of Wyoming*—are hardly used. Second, regional floras now have multiple authors, and even those for states or portions of states often have several contributors. While multiauthored works often result in highly variable taxonomic treatments between groups, there is often a greater consistency between publications because the same specialist is invited to contribute treatments for several works. The *Manual of the Vascular Plants of Texas* was one of the first multiauthored volumes in the modern era, although the unfinished *Contributions Toward a Flora of Nevada*, begun in the 1940s, was earlier. This trend will reach its pinnacle in the revision of Jepson's *Manual* for California and in the new national flora for North America north of Mexico.

#### THE EVOLUTION OF BOTANICAL INSTITUTIONS AND THE FRONTIER HYPOTHESIS

The evolution of institutions on the frontier was, like that for explorations, time-related and influenced by developments in adjacent regions of settlement. The first scientific societies began in 1660, but such modern institutions as the British Museum were not established until 1753. Governmentally supported research in Britain began in the 1770s and gradually replaced that which had been privately funded in the past. In the eastern United States, individuals with modest libraries and collections were not uncommon in the formative years of the nation, but few could afford to send out major expeditions. Thus, the federal government, rather than a group of individuals, a society, or an institution, sponsored the Lewis and Clark expedition.

Few specimens gathered in temperate eastern

North America remained in the New World. The majority went to England and France where they were incorporated into private and public collections. When specimens did remain, they were too often lost or destroyed. The first set of John Clayton's Virginia plants, his Ehret drawings, and his library and manuscripts were burned by the British during the Revolutionary War. Still, the herbarium of Stephen Elliott at The Charleston Museum, established in 1773, has managed to survive.

The privately held collections of Henry Muhlenberg, William Barton, and others in the Philadelphia area formed the nucleus of the Academy of Natural Sciences, which was established in 1812. Many private collections were eventually housed at universities along the Atlantic seaboard, with Harvard, Yale, Columbia, and Princeton having major herbaria early in their histories. The Gray Herbarium at Harvard University, formally established in 1864, had a long prior history thanks to the efforts of Nuttall, Gray, and others. Even the herbarium at the Smithsonian Institution was active before its formal date of establishment in 1868.

The tradition eastern institutions inherited from Europe was one dominated by influential men in positions of power. Prior to 1776, most of those in power in Europe were also wealthy. In the United States, a monied class did not exist so that institutional power came from a combination of position and education. By the 1830s and 1840s, when Torrey and Gray dominated systematic botany, European institutions had evolved to the point that talent too was more important than wealth. Britain's Bentham and Hooker were not poor in any sense of the term, but both were sufficiently talented to dominate taxonomy regardless of their individual monetary worth.

In the United States, as systematic institutions began to form nearer the western frontier, Torrey and Gray dominated the field and virtually controlled all who collected and published. They chose who was appointed to government-sponsored expeditions, and not surprisingly, saw to it that all of the collections generally went to them for identification and publication. When Kellogg and his associates established the California Academy of Sciences in 1853, and Englemann and Shaw joined forces to form the Missouri Botanical Garden in 1859, their activities were blessed by Gray.

Systematic institutions in the United States gradually became fragmented with the establishment of competing government, museum, and university herbaria. Because museums were found primarily on the East Coast, university herbaria (with the exception of Harvard) there generally failed to



become major centers of power. Even when the systematic community began to fragment regionally, no university herbaria in the East was able to dominate floristic and systematic research to the extent that the Smithsonian, Harvard University, and the New York Botanical Garden had done.

In the Midwest, university and museum herbaria, more isolated but not totally divorced from their eastern counterparts, began to expand their circles of influence so that they could produce significant regional floras, but these efforts were minimal until the 1960s. On the Pacific Coast, university herbaria competed directly with local museums and botanical gardens for support, adjusted with them to the changing requirements of systematics, and yet often failed to cooperate. Still, one survival strategy was for university herbaria to concentrate on monographic research, with museums and botanical gardens devoting their resources to floristics.

The regional sectionalism that resulted after Gray's death in 1888 was exacerbated by the institutional infighting between Harvard and the Smithsonian Institution over the demand by the Smithsonian for the return of collections made on federally supported western expeditions. With the increased independence of western botanists, the sudden growth and the attempted domination of the eastern elite by the New York Botanical Garden caused additional bitterness. This came in the form of New York's rapid domination of floristic regions previously considered to belong to Harvard or the Smithsonian. To protect its interests, each institution made further demands upon universities, taxonomists, and editors for allegiance and support for their particular points of view.

The development of class and regional sectionalism are natural stages in the evolution of institutions. Like the individuals at them, there was a concomitant increase in conservative views, with occasional attempts by the major institutions to dominate, or at least control, the ideas and concepts that were evolving on or near the frontier. The small western institutions argued that the eastern establishment was attempting to control floristic studies at the state and regional level. Yet these institutions had the collections, libraries, and type material to do the work. They also had the talented scientists with the time and funding to accomplish the tasks. While local florulas were left to the state universities, most western floras were worked on with the permission of or in concert with a major eastern institution.

By 1889 the so-called eastern establishment had expanded to include the California Academy of

Sciences and the Missouri Botanical Garden, with a few universities, such as the University of California at Berkeley, assuming major leadership roles in systematic botany. Smaller institutions in the West were often under the direct influence of one of these larger institutions, and good working relationships between them were common. For individual western collectors the truce was anything but smooth, yet most became associated with one of the establishment institutions. Greene, a festering sore in Gray's side, went to the California Academy, then Berkeley, and finally to Washington, D.C., where he used the facilities of the Smithsonian. Jones worked as a collector for the federal government and identified his collections at the Smithsonian. He also published initially in journals controlled by the Academy and by Jepson. Heller, isolated at the University of Nevada, collected for the federal government, then for the Academy, and finally for the New York Botanical Garden.

In each instance, the lure of a larger institution was overwhelming even to the most argumentative of the independent naturalists.

Specimen exchange programs soon developed among most of the institutions, with the majority of specimens moving from the smaller herbaria to the larger ones. As the frontier moved westward, those near the edge gradually became the favored repository of the local collectors because by then they had enough of a library and herbarium to serve their needs. Large herbaria soon developed at most of the land-grant universities. Herbaria at the University of Washington (1880), the Rocky Mountain Herbarium at the University of Wyoming (1889), the University of Arizona Herbarium (1891), and the herbarium at the University of Texas (1900) were quick to grow and dominate floristic and monographic research efforts in their respective regions.

Unlike the general success of the major institutions to attract large collections and talented scientists, the success of the smaller ones was usually dependent upon the personality and ability of a single taxonomist. The growth and success of university herbaria such as the Intermountain Herbarium at Utah State University was due largely to the efforts of Maguire and Holmgren, its first two curators. Likewise, the enormous growth of the herbarium at Brigham Young University since 1965 can be credited to Welsh.

Throughout the West there was a step-like evolution of people and institutions as the floristic wilderness disappeared. General collectors were replaced by more regional collectors who were then replaced by monographers. As taxonomy became



more sophisticated, the monographers were replaced by experimentalists so that now, at least in many universities, few systematists are knowledgeable of even the local flora.

Even the teaching of systematics has changed. In the past students were first introduced to the regional flora, often writing a master's thesis of a particular area. Once having gained first-hand experience with several groups of plants and the cognate literature, the student went on for a doctoral degree specializing on a genus. This changed in the 1960s and 1970s, so that now few students are familiar with any local flora, and many have little experience beyond the species level because most do their doctoral research only on a portion of a genus. Likewise, many students today have only a limited knowledge of nomenclature, plant families, the botanical literature, and almost no sense of the past.

Nonetheless, modern innovations in systematics over the past 50 years have tended to come from the university community with its young and aggressive faculty and innovative students. Several have taken a leadership role in certain areas. One example was the development of chemosystematics by Ralph Alston and Billie Turner at the University of Texas. Leslie Gottlieb at the University of California at Davis did much to establish electrophoretic techniques as a useful tool in systematics, and Douglas Soltis, Christopher Haufler, and Gerald Gastony are all currently making fundamental contributions to the field at their home institutions.

The frontier hypothesis predicts that the established, more conservative institutions will periodically attempt to specialize and diverge from their established missions. In doing so, those with strong traditions for change will succeed as long as the specialization does not threaten the institutions' main missions. Many, however, will fail or at least wane and fall from prominence, with influence and power shifting to more dynamic institutions. The hypothesis states that such dynamic institutions will always be closer to the frontier.

Universities with large and diverse faculty in systematics tend to be successful in changing emphases and maintaining successful programs simply because of their size. Whether or not they retain their position in systematics depends to what extent they abandon their traditionally strong areas of research. Interestingly, where the systematics staff is small, the institution tends not to rid itself of the service aspects of its taxonomist; rather, it allows the other necessary academic disciplines, such as anatomy, cytology, morphology, and paleobotany,

to fall aside, thereby preventing continuation of a viable graduate research program.

The national disappearance of botany departments and the demise of organismal biology on university campuses may seem to discount the above assertions. Still, many administrators realize that for an institution to become "modern," it must be at the expense of the classical fields, and thus it becomes a philosophical question whether their traditional mission should be fulfilled. To avoid this uncomfortable question, administrators tend to establish isolated "institutes" so as to divorce their researchers from the day-to-day routine of dealing with academic matters. Classical scientists are therefore retained in teaching and service positions with limited in-house funding—well isolated from the activities of those who are considered to be doing real science. This results in internal sectionalism, which is often coupled with profound personal bitterness among the individuals.

Mature museums and botanical gardens, in an effort to be on the cutting edge in research, often fail in their community responsibility of being a primary resource center. When they attempt to follow fads, and available research dollars, by hiring narrowly trained specialists in peripheral, often exotic fields, it is typically done at the expense of those people who are familiar with plants and whole floristic regions of the world. The newly hired curators, to remain competitive, cannot afford to be interested in collections, exchange programs, or large-scale fieldwork. As a result, the primary mission of the institution is not fulfilled, to the distress of others who depend upon its accumulated resources. For those who remain, there is a lessening of available funding as the institution fails to attract the research dollars needed to operate its exotic programs, and with fewer broadly trained staff, it can no longer maintain its position of importance. This often results in internal classism with accusations and condemnations that can only hasten the demise of the institution.

The underlying force behind all of these predictable trends, according to the frontier hypothesis, is the lack of a near frontier. Researchers once interested in the wilderness flora of temperate North America are now working in the tropics, where there is still a substantial floristic frontier. Institutional interests at all levels, but particularly those in the larger national and regional museums, botanical gardens, and universities, have always been on the frontier, and today that means the tropics. Funding agencies, and those few systematists who control the dispersal of research funding,



are often guilty of concentrating available funding on the latest fad, arguing that this is the only way they can justify their budgets to the administration and to Congress. The disquieting trend, and the one that must be fought, is the tendency with maturity to assume that the work done on the old frontier should end simply because the excitement and challenge of the frontier are gone.

#### BEYOND THE AMERICAN FLORISTIC FRONTIER

What is the future of systematic botany in temperate North America, especially in the continental United States, now that there is no longer an unknown wilderness beyond a floristic frontier? According to the frontier hypothesis, we can expect a consolidation of institutions and a reduction in their numbers. We can expect a greater conservativeness to envelop the field, especially as it relates to nomenclature and other aspects of classical taxonomy, including floristics. While the natural evolution of technology will continue to be exploited, its application will be restricted to fewer individuals and fewer institutions. Furthermore, the half-life of any new fad will shrink, with most contributing little to our broad understanding of evolution and systematics.

These trends are predictable and will come to pass. Policies to prevent them will not succeed and generally will not be attempted. The problem to be addressed by those who work on the temperate flora is how do we proceed? Predictably, we must consolidate our research efforts, reduce our expectations, and sacrifice knowledge on the biology and natural history of all our plants in favor of being permitted to evaluate a few.

In short, to work on the plants of this newly settled region we must do precisely what the frontier hypothesis says we will, even with the predicted adverse consequences.

Sectionalism will increase, exacerbated by the haves and have-nots. Instead of the kind of sectionalism now found, it will evolve into one involving national versus international interests. Large, multi-institutional international projects will dominate systematics at the expense of individual scientists examining a single group of plants. Even monographic work will change, with funding going primarily to those who put together a team of scientists to accomplish what one, in the past, could have done just as well at far less expense. Still, with the demise of the classical "herbarium taxonomist," there will be such a profound loss of knowledge that it will take years to recover that traditionally

inherited "institutional" knowledge of the plant kingdom so many have been able to learn simply by having a willingness to work and listen.

The frontier hypothesis predicts many of the best and brightest will continue to work on and beyond the floristic frontier wherever it exists. Funding in the future, as in the past, will continue to go preferentially to projects on the frontier. And technology will continue to drive the funding.

On the international level, the American systematic community must remember that while the United States no longer has a floristic frontier, other nations in the Americas do. We must be willing to address the concerns and needs of those still on the frontier. Much as we resented the exploitation of our wilderness flora by the Europeans in the past, so too do those on the frontier resent exploitation by American systematists today. We have done much to address the concerns of others; yet, we must do more and to do so will be costly. That means an effective transfer of funds, people, and knowledge must occur.

We must also be aware that the amount of time for each evolutionary stage to occur on the remaining frontiers will be much faster in the future. It took some three centuries for the floristic frontier to move to the base of the Rocky Mountains and the Sierra Nevada, but only one to eliminate the remainder of the wilderness across the Great Basin of the American West. With the rapid, exploitative destruction of the tropics, we have little time to make even the most basic observations on the native vegetation before it will be so altered that its significance will be lost forever. Therefore, a degree of urgency does exist—which did not exist in 1889—and if we are to gain any useful knowledge of the plants found in many of the world's last remaining wildernesses, we must act as any adventuresome taxonomist would: head for the frontier! That is where the challenge is; that is where the research dollar is.

#### CONCLUSION

In this symposium we have commemorated a century of botany, 1889–1989. The changes that have occurred over the century since Turner proclaimed the close of the American frontier have been great. A maturation of people, institutions, customs, and traditions is predicted by the frontier hypothesis. We should continue to improve well into the future as long as systematists and systematic institutions do not become so rigid that they cannot change with the times.



The past century of botanical exploration has brought us to the point in our evolution that, like this nation a century ago, we too are in a position to expand and mature. We do not yet need to fear rigidity, but we do need to be cautious. Indeed, we will experience advances similar to those of the nation since 1890, but in a much shorter period of time. If our future is not to be dim, we must be alert. How we direct our future, and how much we

are willing to invest in the maturation of our nation's floristic and systematic community, must be something we decide. To leave it to a few, or worse yet, to outsiders, means that we are forgetting one of the most important lessons of the frontier: to be free is to have liberty, and to have liberty means we must participate in the processes that give it a voice.